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Configuration study for a spaceborne Advanced Hyperspectral Imager (AdHYSI) for Agriculture, Mineralogy and Environmental applications

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Abstract

Spaceborne hyperspectral imaging sensors have found potential applications in agriculture science and mineralogical mapping of Earth surface. Recently, there is a growing interest in using spaceborne hyperspectral data to study impact of agriculture and mining activities on Earth environment. The prominent spectral signatures from bio-geo-sphere lie in the 400 to 2500 um range of electromagnetic spectrum and a hyperspectral sensor with fine spectral sampling in this range along with moderate spatial and high temporal resolution can pave way for enhancing current scientific understanding on various physical processes involving agriculture, mining and environment as a coupled system. Globally various hyperspectral sensors such as Hyperion, Envisat, HYSIS, etc have been designed and operationalized for agriculture, mining and environmental studies. There are several technological challenges in design and development of these efficient hyperspectral imaging instruments such as covering large spectral range using a single instrument, achieving higher spectral resolution, radiometric accuracy, and high SNR in all bands. Due to tremendous progress in detector fabrication technology, area array detectors operating in broad spectral range of ~400-2500nm are now available, which can facilitate design and development of hyperspectral imager with a single instrument. Using innovative design and usage of state-of-the-art electro-optical components (e.g. detector, grating, filter), challenges can be mitigated.

The present research work proposes an optical imaging spectrometer based on broadband MCT based cooled detector and convex blazed grating to provide spectral resolution of better than 10nm in the entire operating spectral range of 400-2500nm. Targeted SNR is more than 300 for majority of the spectral range with radiometric resolution of 12 bit. The instrument is configured to provide 20-30 m spatial resolution and about 20-30 km swath from LEO platform of about 500 – 600 km altitude and offers 4 days revisit capability with anticipated mission life of about 5 years.

This paper first discusses the application requirements, presents the system configuration details of the proposed AdHySI instrument along with the details of optics, detector, electronics, mechanical and thermal sub-systems. The study brings out various design and realisation challenges and discusses mitigation approaches. The proposed instrument configuration is based on the current international trend in hyperspectral instrument technology and has realisation feasibility. The proposed instrument has potential to become a state-of-the art spaceborne hyperspectral instrument for agriculture, mineralogy and environmental studies.

Table 1. AdHYSI Instrument Parameters

Sr. No.	Parameters	Values
1.	Spectral Range	400 – 2500 nm (Single instrument)
2.	Spectral Sampling	5-10 nm
3.	Spatial Resolution	20-30 m
4.	Swath	20-30 km
5.	Radiometric performance	> 300 SNR
6.	Calibration Accuracy	< 5%
7.	Temporal resolution	4 days revisit
8.	Dynamic range	100 % albedo
9.	Quantization	12 bit
10.	Life	5 years

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